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Species diversity, habitat association and abundance of avifauna and large mammals in Gonde Teklehimanot and Aresema monasteries in North Gondar, Ethiopia

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Studies on species composition, distribution and relative abundance of birds and mammals in Gonde Teklehimanot and Aresema Monasteries was carried out from December, 2015 to February, 2016. In these areas, wildlife conservation is directly relevant to the local community, often as a source of livelihood, medicine and spiritual values. To collect data on population status of large mammals, we commenced a line transect while date on distribution, species composition and habitat association of Avifauna were collected by using a point transect, or point count in both Gonde Teklehimanot and Aresema monasteries. Based on these, a total of 95 and 72 species of birds and 21 and 9 species of mammal were recorded, respectively. Duncan's Multiple Range Test showed that mean number of species did significantly differ between the two study sites. However, mean no. of species between habitats did not show a significant in both study areas. During the dry season, the highest species diversity at was recorded in farmlands and its associated habitat, 0.93 and followed by Riverine bushland, 0.75. This might be correlated with the less habitat diversity; i.e a homogenous (Ticket forest) habitat type is a dominantly habitat type in the area. Among the monastries, Gonde Teklehimanot was better in mammalian and Avifauna diversity than Aresema monastery. Both of them are rich in biodiversity, and hence, conservation practices and management innervations should be done at different levels of the local communities.

Key words: Gonde Teklehimanot, Aresema monasteries, species.

INTRODUCTION

Ethiopia is a country endowed with unique endemic fauna, flora and forest resources (Bongers et al., 2006). The sacred monasteries of the Ethiopian Orthodox Church is one of the oldest Christian identities in Africa,

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and has a long history of protecting and preserving indigenous flora as sanctuaries for prayer and burial grounds for church followers (Wassie et al., 2009). In a general sense, the biodiversity found in the monasteries are seen as sacred, with the trees symbolic of angels guarding the monasteries. However, at the community-level each monastery and church operates largely autonomously, with its own contextually-defined approach to natural resources management (Wassie et al., 2010).

Biodiversity would have spiritual, economic, aesthetic, cultural and scientific functions for the local community. Biodiversity conservation is directly relevant to the local community, often as a source of livelihood, medicine and spiritual values. However, it is difficult to reconcile these values. As biodiversity conservation is a precondition for sustainable development, cultural and biological diversity are necessary and equally important prerequisites for sustainable development (UNESCO and UNEP, 2003).

Besides, the recognition of the *cultural and spiritual values* are important factor to enhance the biodiversity conservation efforts, that is, if the people know the cultural significance of wild plants then they would have a crucial role to conserve the biodiversity (Dold, 2006). However, the findings of many anthropologists and sociologists on small-scale societies showed that commonly owned biodiversity are conserved not only by rational institution created for the purpose of economic utilization of resources, but also by various cultural elements like kinship, religion and social organization, which also played vital role in the conservation. Therefore, the recognition of the cultural and spiritual values is an important factor to enhance the sustainable biodiversity conservation efforts.

The holy places have survived for many centuries as islands of biodiversity in a sea of deforested landscape across the Ethiopian highlands (Tamire, 1997). The remaining parts have been occupied or converted into agricultural lands. Biodiversity surveys in monasteries and churches indicate that the holy place serve as key refuge for the endangered plant and animal species (Wassie, 2004; Ermilov et al., 2012).

Monasteries can also be used as site for *in situ* conservation of the endemic species as a seedbanks for native plants that have otherwise vanished from the region (Aerts et al., 2006). In addition, monasteries provide important ecosystem services to local people, including fresh water, honey, shade and spiritual value. It also harbours vast insect biodiversity (Ermilov et al., 2012), providing pollination and hydrological services for nearby farmlands (Lowman, 2011).

The monasteries are among dry evergreen patchy remnant forests. In spite of their ecological and spiritual benefits, due to a combination of economic, environmental, and cultural factors, the integrity of the monasteries forest like many other sacred natural sites has continued to decline. The monasteries forests are decreasing in both size and density, with visible losses in biodiversity due to livestock grazing, fuel wood harvesting and other pressures (Wassie et al., 2010).

Grazing in particular, causes irreversible damage through consumption and trampling of seedlings, soil compaction and erosion (Wassie et al., 2009). Moreover, as small forest fragments are degraded, biodiversity suffers even further from physical edge effects such as lightintensity, wind and temperature variability, and reduced soil moisture and humidity (Aerts et al., 2006).

Like other sacred natural sites, the dwindling of biodiversity in these monasteries has begun to attract regional attention, and now advocate prioritization of these sacred natural sites for conservation. Prioritizing the area for conservation of biodiversity is highly needed, and should be based on sound knowledge of succession pathways of existing ecosystems.

North Gondar Administrative Zone is endowed with a number of ancient churches and monasteries. Among the sacred natural sites, or monasteries that are found inthis Administrative Zone are Acholake Eyessus, Beri Mariyam, Mehaber Selase, Gonde Teklehimanot and Waldeba monasteries (Wassie et al., 2009). However, monasteries are influenced by different anthropogenic activities. In such a shift from a “purely rural” to “industrially rural” society, the need for rural development to be sustainable becomes paramount (Ivolga and Timofeeva, 2014). Sustainability for monasteries areas is more than just a sustainable economic growth (Aerts et al., 2006). The concept of sustainability in monastery areas should integrate environmental, economical, cultural and social factors.

To overcome the problems in biodiversity loss in and around the selected monasteries, stakeholders play vital roles in conservation activities, and are considered as clients to minimize the risk of biodiversity loss. In this context, team members had undertaken intensive research on flora and fauna diversity of the monasteries. In addition, team members undertook the implications of culture and religious on conservation of biodiversity in Gonde Tekelhamanot and Aresema monasteries.

Study area

The present investigation was carried out in Gonde Tekelhimanot and Aresema Monasteries. The study areas are located at the eastern flank of Gondar ridge. Gonde Tekelhimanot is located at an altitude of 2,361 m, 12°24′ 65″ N latitude and 37°41′ 67″ E longitude (Figure 1). Aresema monastery is located west of Gond Tekelhimanot and north of Makesgnt town, near ‘‘Burboakse’’ village at 12°23′ 612″ N latitude and 37°40′ 516″ E longitude (Figure 1).

The ridges of the holy place that surrounds in all

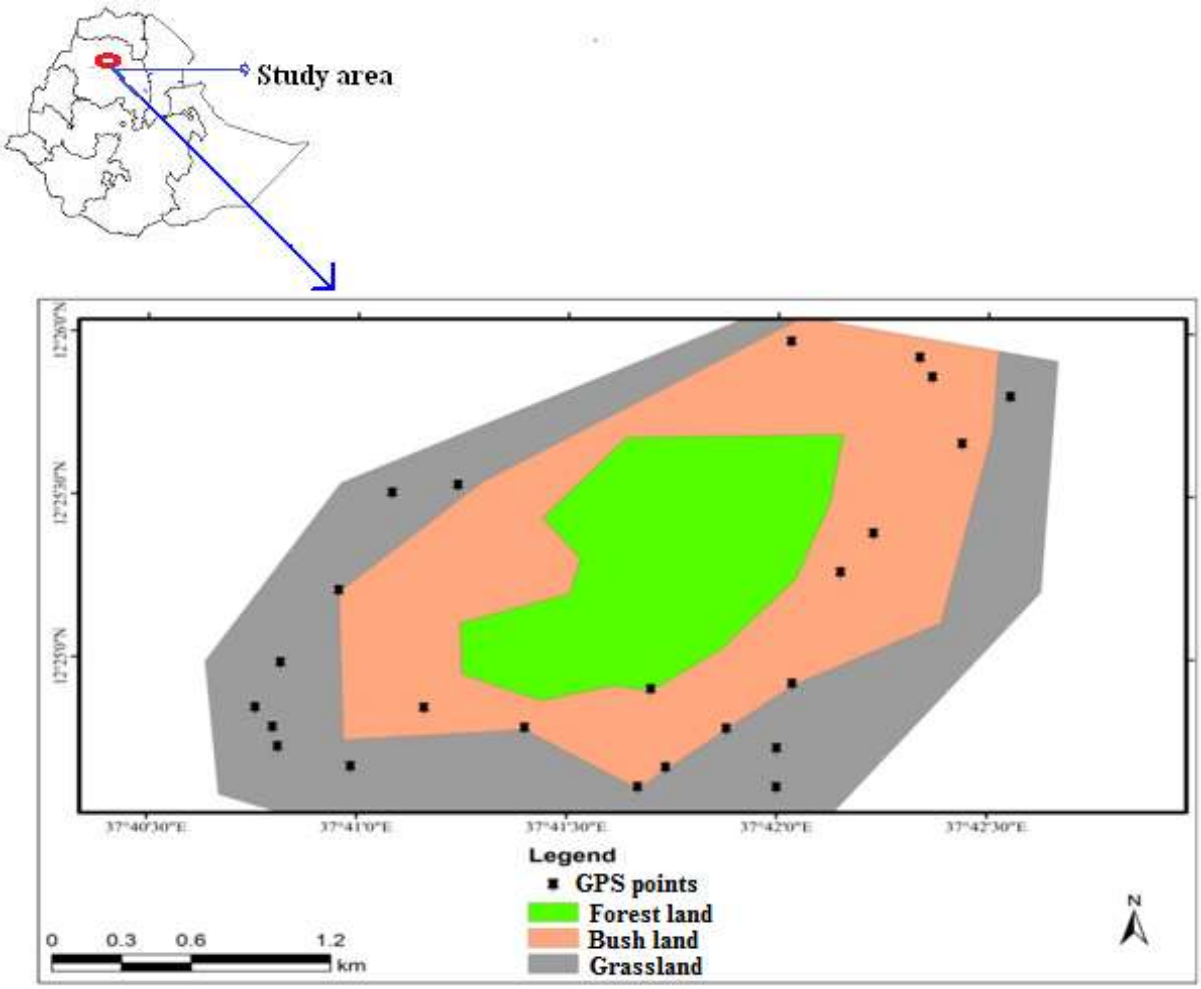

Figure 1. Map of Gonde Teklehimanot monastery.

direction of the monastery shows prominent volcanic activities had occurred in the past several decades of millions of years. There are variations in the habitat diversities of the two study sites. In general, Aresema monastery is relatively less diverse in habitat compositions as compared to Gonde Teklehimanot, where ticket forest is predominant in the area. The distribution of rainfall in the study sites is characterized by a unimodal pattern that occurs during June to September. Average annual rainfall is around 1,440 mm. The study sites possess a complex mix of highland climate zones, with temperature differences of upto 10°C, depending on elevation and the wind patterns. In the high elevation area, temperature is moderate year-round. As the study area is located near the equator, temperatures are more or less constant from month to month. The temperature during the dry season ranges between 22 to 28°C, and during the wet season between 15 to 17°C with an average annual temperature of around 16°C.

METHODOLOGY

Line-transect, focal sampling and point-count methods were used to collect data on birds and large mammals during the present investigation. Surveys were conducted during December 2015 and February 2017. Data collection was carried out during 07:00 to 10:00 h in the morning, and 16:00 to 18:00 h in the evening, when activities of birds and mammals were more prominent.

Birds were identified using field guide of Alden et al. (1995). Transect surveys were made walking slowly along the long axis of the study site treks, and all individuals and species of birds and large mammals observed were recorded. The mean time spent per transect during the survey was 60 min. A total of eight point-count locations (1 to 8) were marked in the study area, each located approximately 300 m away from one another, for detailed observations. Counting sites were made on the transect in each habitat types, forest, open wood land, riverine forest and ticket forest.

At each of the point count locations, all birds seen or heard within a 25 m radius were recorded. To collect data on abundance, repeated observations were made. For population estimation of large mammals and geladas, sweep census technique was used

Table 1. Habitat association of large mammals in GondeTeklehimanot monastery.

Common name	Species name	Habitat types			
		Riverine forest (I)	Grassland(II)	Forest(III)	Open woodland(IV)
Kelip springer	*O. oreotragus*	*	√	*	√
Grey Duiker	*S. grmmia*	√	√	√	√
Rock hyrax	*P. capensis*	*	*	√	*
Leopard	*P. paradus*	*	*	√	*
Common jackal	*C. aureus*	*	√	*	√
Egpt. Mongoose	*H. ichneumo*n	*	*	√	*
African Civet	*V. civeta*	√	√	√	√
Gelada monkey	*T. gelada*	*	√	*	*
Hamadryas baboon	*P. hamadryas*	*	√	*	√
Honey Badger	*M. capensis*	*	√	*	√
Spotted hyena	*C. crocuta*	*	√	*	√
Vervet monkey	*C. aethiops*	√	*	√	*
Aardvark	*O. afer*	*	√	*	√
Wild pig	*S. scrofa*	√	√	√	√
Menlik bush buck	*T. s. meneliki*	*	*	√	*
Unstriped grass rat	*A. abyssinicus*	*	√	*	*
Striped hyena	*H. hyaena*	*	√	*	√

*, absent; √, present; *P. capensis* and *P. paradus* associated with cliffs with forest.

(Beehner et al., 2008) regularly at least once per counting session in each of the study sites across the study period, covering both wet and dry seasons. Geladas and other large mammals were followed walking slowly from a distance of around 50 to 100 m, and data were collected by means of instantaneous scan samples (Altmann, 1974).

In contrast, geladas in rugged and cliffy areas were observed using binoculars at a distance of around 300 m. The study units were differentiated from others by unique body marks on their body and by their sleeping sites. Intact units in different sites were checked every day in order to collect data about population structure and behavioural activities. Data were collected between 07:30 to 18:30 h. Focal samples were observed at random, and the observed activities were recorded during the interval periods.

Shannon-Wiever diversity index (H') and Simpson's similarity Index were used to determine the diversity of species in each habitats in the study areas, hence, SI = 4C/I +II+III+IV,SI = 4C/I +II+III+IV, where I= the number of species observed in riverine habitat, II = the number of species observed in grassland habitat, III= the number of species observed in forest habitat, IV= the number of species observed in open woodland, and C = the number of species common to all habitats.

Data analyses

All statistics related to the types of data were carried out on statistical package for social sciences (SPSS) 20.0 software for Windows Evaluation Version. Statistical tests were one tailed with 95% confidence intervals. Simpson's similarity index was used to compare species diversities between habitats in both study areas. F test was used to compare species composition of birds in dry and wet seasons, and it was also used to compare the diversity of species between different habitats. Duncan's Multiple Range Test was done to compare the differences in species composition and abundance of birds in each of the point count locations, and to find out differences of species composition between two study areas.

RESULTS

A total of 95 and 72 species of birds were observed during the wet and dry seasons in Gonde Tekelhamanot and Aresema monasteries, respectively. Nearly 20 endemic species of birds are identified in both study areas. A few Palaearctic Migrants and Intra-African Migrant were recorded during the study period. Most of the Palaearctic migrants were observed from December 2015 to June 2017, mostly in the cliff and mountains habitats of Gonde Tekelhamanot monastery. Nearly 52 bird species were common to both Gonde Tekelhamanot and Aresema monasteries, and seasonally, 65 and 32 species were exclusive to the dry and wet seasons, respectively.

Simpson's similarity index, in different habitat types shows high similarity in species composition, the value, 0.43 is closer to zero. In addition, in Gonde Teklehimanot monastery grassland habitat types are more diverse in species composition followed by open woodland, while the riverine forest habitat type is less diverse in species composition than other habitat types (Table 1).

The species composition of birds during the dry and

Table 2. Avian species diversity during wet and dry seasons in GondeTeklehimanot monastery.

Study site	Habitat	Seasons	Number of species	Number of individuals	D	H'	H'/H'max
Gonde Teklehimanot	Forest	Wet	41	470	0.52	1.72	0.26
		Dry	39	390	0.62	4.56	0.52
	Riverine forest	Wet	18	212	0.73	3.97	0.29
		Dry	17	198	0.61	5.21	0.38
	Woodland	Wet	25	167	0.81	3.41	0.72
		Dry	24	142	0.67	1.05	0.64
	Bushland/scrub	Wet	14	115	0.68	2.14	0.81
		Dry	12	98	0.72	1.67	0.37

H' = Shannon_Wiener index; H'/H'max= evenness; D= diversity Index; H'max= ln (s).

Table 3. Number of bird species in different relative abundance categories.

Study site	Habitat	Seasons	Frequent	Common	Abundant
Gonde Teklehimanot	Forest	Wet	23	11	7
		Dry	17	14	10
	Riverine forest	Wet	9	6	3
		Dry	10	5	2
	Woodland	Wet	14	7	4
		Dry	13	8	3
	Bushland/scrub	Wet	8	4	2
		Dry	7	3	2

wet seasons was not significantly different (F_1, 95 = 0.24, $p > 0.05$), but there was a significant difference among habitats (F_2, 95 = 2.23, $p < 0.05$). Season and habitat interaction was, however, not significant (F_2, 95 = 0.12, $p > 0.05$). Duncan's Multiple Range Test showed that mean number of species did significantly differ between the two study sites. However, mean number of species between habitats did not show significance in both study areas. In forest habitat (Gonde Teklehimanot), mean number of specie was 40 (= 0.387, n = 40) and in Aresema, mean number of species was 20 (= 0.397, n = 20); whereas, the riverine habitat (mean number of species = 0.046, n = 18) was significantly different from the two study sites. The highest species diversity (D) during the wet season was observed in woodland (0.81), followed by riverine forest (0.73) (Table 2).

The relative abundance scores of species in forest habitat showed that 23 and 17 species were frequent; 11 and 14 were common; 7 and 10 were abundant in wet and dry seasons, respectively. The abundance scores of the species in riverine forest showed that 9 and 10 were frequent; 6 and 5 were common; 3 and 2 were abundant in wet and dry seasons, respectively. In woodland habitat type, the abundance scores of the species showed that 14 and 13 were frequent; 7 and 8 were common; 4 and 3 were abundant in wet and dry seasons, respectively. Whereas in Bush-land/scrub 8 and 7 species were frequent; 4 and 3 were common; 2 species were abundant in wet and dry seasons (Table 3).

Similarly, the species composition of birds in Aresema monastery during the dry and wet seasons was not significantly different (F_1, 68 = 0.32, $p > 0.05$), but there was a significant difference among habitats (F_2, 68 = 3.21, $p < 0.05$). The Ticket forest habitat had the least species diversity, 0.58 as compared to other habitat types. During the dry season, the highest species

Table 4. Avian species diversity during wet and dry seasons in Aresma monastery.

Study site	Habitat	Season	No. of species	No. of individuals	D	H'	H'/H'max
Aresema monastery	Ticket forest	Wet	29	380	0.58	1.67	0.28
		Dry	27	265	0.62	4.82	0.47
	Woodland	Wet	17	169	0.78	3.96	0.29
		Dry	15	142	0.72	4.21	0.36
	Riverine bushland	Wet	14	210	0.64	3.86	0.68
		Dry	13	178	0.75	1.23	0.56
	Farmland	Wet	11	134	0.68	2.31	0.81
		Dry	10	105	0.93	1.72	0.41

H' = Shannon_Wiener index; H'/H'max= evenness; D= diversity index; H'max= ln(s).

Table 5. Number of bird species in different relative abundance categories in Aresma monastery.

Study site	Habitat	Season	Frequent	Common	Abundant
Aresma monastery	Ticket forest	Wet	16	8	5
		Dry	14	9	4
	Woodland	Wet	9	5	3
		Dry	7	5	3
	Riverine bushland	Wet	6	5	3
		Dry	5	6	2
	Farmland	Wet	4	5	2
		Dry	5	4	1

diversity was recorded in farmlands and its associated habitat (0.93), and followed by Riverine bush land (0.75). The highest species evenness was registered in the farmland habitat type (0.81), followed by Riverine bush land (0. 68). However, in both wet and dry season's the woodland and farmland habitat types had better species diversity, 0.75 and 0.78, respectively (Table 4).

The relative abundance scores of species in Ticket forest showed 16 and 14 species were frequent; 8 and 9 were common; 5 and 4 were abundant in wet and dry seasons, respectively. The abundance scores of the species in woodland showed 9 and 7 were frequent; 5 were common and 3 were abundant in wet and dry seasons. In riverine bush-land habitat type, the abundance scores of the species showed that 6 and 5 were frequent, 5 and 6 were common; 3 and 2 were abundant in wet and dry seasons, respectively. While in farmland, 4 and 5 species were frequent; 5 and 4 were common; 2 and 1 were abundant in wet and dry seasons, respectively (Table 5).

DISCUSSION

A total of 95 and 72 species of birds were recorded in Gonde Teklehimanot and Aresema monasteries, respectively. In addition, the study sites also harbour over 20 species of mammals. Among them, two species are endemic and 4 species are threatened while the others are least concern. High abundance of birds was recorded in dense and ticket forest habitat types in the study areas. While the lowest abundance was recorded in bush-land and farmland habitat types. These might be related with the fact that forest habitats are much conducive than scrub/bush-land and farmland for birds in the availability of food and roosting sites. Similarly, Timossi and Manley had reported that forest habitat is much better in diversity of bird species as compared to other habitat types. In addition, Girma et al. (2016) reported that bird diversity and abundance are high in forest habitat types.

The species diversity in both monasteries did not show a significant variation between wet and dry seasons. This

might be related with species diversity, or number that has no direct relationship with seasonal variations rather it has a significant impact on population size of mammals and birds. Green and Hirons (1991) had reported species richness of wildlife may not vary with respect to seasons rather abundance and population size significantly vary in different seasons due to the variation in food availability.

The relative abundance scores of species with respect to seasonal variation did not show any significant change in both monasteries. However, abundance scores of species were varied between habitats. These might be due to the variations in resources/food availability between habitats. Similarly, EWNHS (1996) reported that food availability can determine the variation in abundance of birds' species between habitats. Baker et al. (2010) also reported that variation in abundance of bird species was observed between different habitats but not between seasonal variations. Large mammal's diversity was also varied between study sites. In species diversity, Gonde Teklehimanot monastery is better in diversity of large mammals than Aresema monastery, this might be related with the variation in habitat diversity.

In practical, Aresema mastery has less habitat diversity and ground cover, and these factors might bring some change in diversity of species. Similarly, Jones et al. (1996) reported geographical location and habitat diversity are primary factors in the richness and abundance of large mammals. Moreover, climatic variability in relation to habitat quality can determine species abundance of large mammals. In line with this, the effects of habitat quality can also determine species diversity and abundance of large mammals in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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